Goddard Space Flight Center
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Technical Support Package

Shared-Aperture Multiplexed Holographic Scanning Telescopes

NASA Tech Briefs
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Technical Support Package

for

SHARED-APERTURE MULTIPLEXED HOLOGRAPHIC SCANNING TELESCOPES

GSC-14240

NASA Tech Briefs

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Shared-Aperture Multiplexed Holographic Scanning Telescopes

BRIEF ABSTRACT

The purpose of this invention is to effect a scanning telescope transceiver, especially a lidar transceiver, or similar receiver or transmitter component(s) in remote-sensing instruments, without using moving parts in order to make a lighter instrument. This is accomplished by using a single optic containing several holographic optical elements to effect multiple fields of view (FOVs) as an alternative to mechanically scanned lidar receivers.

SECTION I – DESCRIPTION OF THE PROBLEM

A. General Description

The objective is to design a scanning lidar transceiver for Earth and planetary remote sensing from spaceborne, airborne, and ground-based platforms that is compact, lightweight, and reliable.

B. Key or Unique Problem Characteristics

Prior methods include Scanning Holographic Lidar Telescopes (US Patent No. 5,255,065), and combinations of conventional reflective and refractive optics to accomplish a scan of a telescope's primary aperture or FOV over angles that are ordinarily much greater than can be accomplished using focal plane scanning mechanisms.

C. Disadvantages of the Prior Art

All of the prior art requires some type of large mechanical means of either moving the entire telescope, or a large optic or optics placed in front of the telescope to scan the primary aperture over a large range of angles. Consequently, all of the prior art requires motors, gearing, and bearings which are of necessity heavy and expensive to implement. For spaceborne applications, these will all typically require angular momentum compensators which entail additional mass and complexity.

SECTION II – TECHNICAL DESCRIPTION

See Attachment A entitled, “Shared Aperture Multiplexed (SAM) Lidar Telescopes,” for the technical description.

SECTION III – UNIQUE OR NOVEL FEATURES

Novel and unique features of this invention include the use of diffractive (holographic) optics in place of a conventional reflective or refractive telescope or telescopes, the multiplexing of several diffractive optics into a single optic, having them optically addressable by virtue of their angular selectivity, and using this property to effect a sequential scan or sampling of various FOVs without any mechanically moving parts.

Its advantages includes the lack of mechanical apparatus to perform the scanning function, the use of a single optic to perform the function of several independent optics, and the concomitant savings in volume, weight, and cost associated with these substitutions.

SECTION IV – POTENTIAL COMMERCIAL APPLICATIONS

Potential commercial applications include airborne terrain mappers and lidar wind shear and wind profiling systems to aid in the safe take-off and landing of aircraft. Houston Advanced Research Center, Woodlands, TX, is one organization already licensing similar technology from Goddard for airborne terrain mapping.

Attachment A

SHARED APERTURE MULTIPLEXED (SAM) LIDAR TELESCOPES

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A new concept is introduced in which a single optic simultaneously acts as several telescopes, each with a separate FOV. Such a device can be used as a substitute for primary aperture scanning and in doing so eliminate all moving parts. Previous work has led to the development of a holographic telescope that produces a conical scan by rotating a flat disk containing a Holographic Optical Element (HOE)[1]. As a result of this work two prototype holographic scanning lidar systems were developed, a ground based system based on a 532 nm reflection HOE[2,3], and an airborne system based on a 1,064 nm transmission HOE[4]. The Doppler wind lidar community is interested in using some sort of diffractive scanner or telescope because it holds the promise of making a much more compact and lighter receiver for wind profiling lidars. There is some agreement within the Doppler lidar community that continuous scanning is not required and that a step and stare approach to gathering data from different look angles may be a preferred approach because it eliminates the need for lag angle compensation in the receiver. Lag angle is due to the fact that the scanner has rotated during the time in takes a light pulse from the laser transmitter to travel to the Earth and back. Not only must the transmitter point ahead of the receiver by the lag angle, but for heterodyne systems, the wave front phase tilt must also be corrected. I propose to develop a holographic telescope system that consists of multiplexed HOES within a single film. Each HOE will have a separate FOV and a separate field stop, placed at differing angles around a circle (Figure 1). In this manner, effectively several independent telescopes can all simultaneously share the same aperture space while looking in different directions.

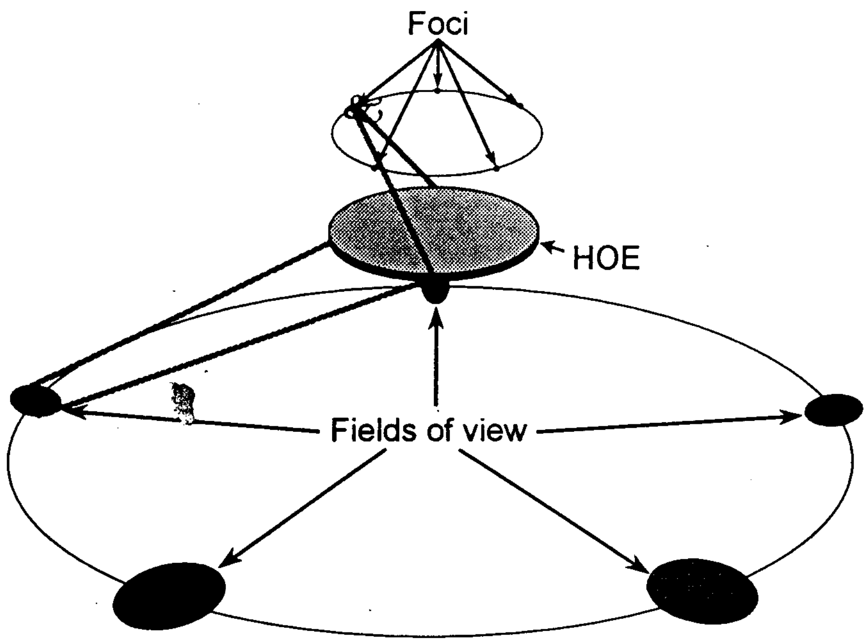

Figure 1

Concept for multiplexing five HOES to act as five telescopes all sharing the same aperture.

Each HOE is optically addressable by transmitting a laser beam through the HOE along the appropriate line of sight, appearing to emanate from one of the field stops. This particular design requires either a separate laser for each FOV or an independent mechanism for steering a single laser beam through each of the virtual field stops. I prefer the first approach, as multiple lasers appear to add the advantage of longer lifetime for the diode pumped lasers currently being used in space. This is because the pump diode lifetime is limited to a fixed number of shots, which depend on how hard the diodes are driven. In order to increase the system life without severely impacting reliability, multiple lasers are preferred as in the Geoscience Laser Altimeter System design.[5]

In an alternative embodiment, the transmitter optics used to introduce the transmitted laser beam into the receiver optic axis can be simplified by using the central portion of the SAM optic for transmitting only. This would be the same type of multiplexed hologram as the receiver, but the focal spots from which the lasers emanate would be offset from the receiver foci. While the area of the transmit HOE is lost for receiving, it needs to be no larger than the area that would be lost due to the obscuration of the optics that would otherwise be needed to introduce the laser into the FOV. The receiver foci may now be superimposed if desired, so that a single detector can be used for all of the receivers. This results in a practical and desirable arrangement, provided the transmitted pulses from the various lasers are sufficiently separated in time so as not to cause the lidar return signals to overlap.

References

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